United States Patent

[11] **3,622,136**

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[32] Priority **Dec. 4, 1968**
[33] **Germany**
[31] **P 18 12 584.3**

[54] **DRIER FOR PARTICULATE OR FIBROUS MATERIAL**
17 Claims, 15 Drawing Figs.

[52] U.S. Cl. .... **263/40 R,** 263/19 A, 415/54
[51] Int. Cl. **F27b 3/10,** F23l 15/04
[50] **Field of Search** .... 263/19 A, 40 R; 415/54

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Primary Examiner—John J. Camby
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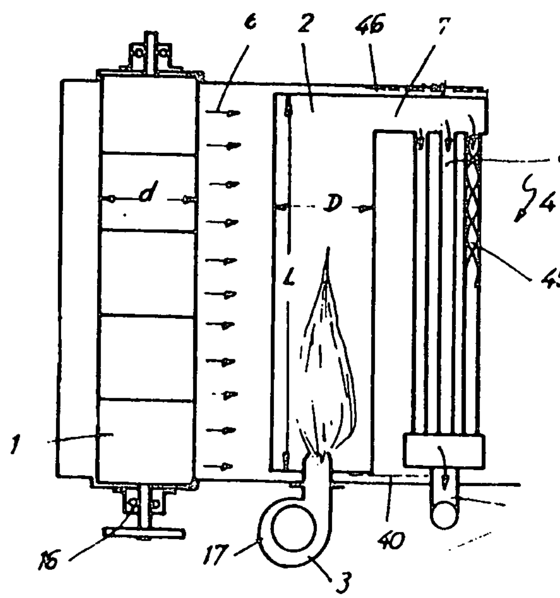
ABSTRACT: A dryer for particulate or fibrous material includes a flow path in which a fan conveys fresh air. The flow path includes a combustion chamber for producing hot gas and a heat exchanger receiving the hot gas, as well as a drying zone which receives the heated air for drying the material in the zone. The fan is a crossflow fan, including a cylindrical impeller, a curved deflector plate and a turbulence flap. The deflector plate diverges circumferentially from the impeller in the direction of the rotation and encloses the impeller for an angle of about 180°. The tangents to the deflector plate at the circumferential ends enclose an angle less than 90°. The turbulence flap has a surface on the suction side which forms with the impeller circumference a channel widening in the direction of rotation of the impeller, which forms an acute angle with a surface of the flap on the pressure side. The channel provides a partial return current of air to the impeller from the pressure side in a direction substantially tangential to the impeller circumference. The axial length of the impeller is considerably greater than the diameter. The impeller combustion chamber and heat exchanger are contained in a casing of a width corresponding substantially to the length of the impeller. Bearing and drive units for the impeller are located outside the casing.



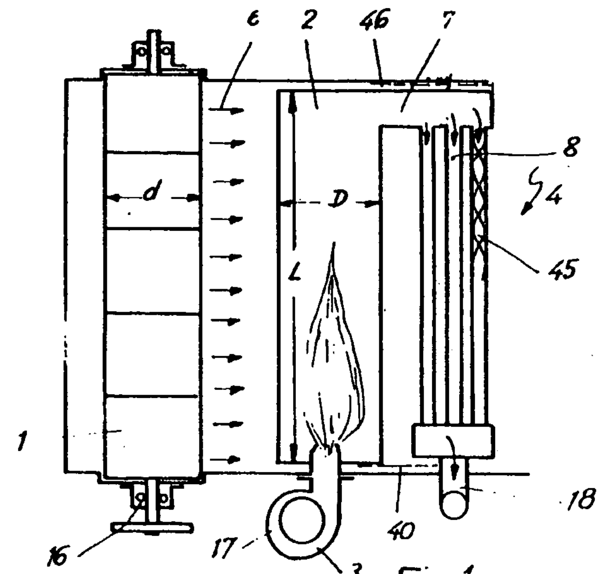


Fig. 1

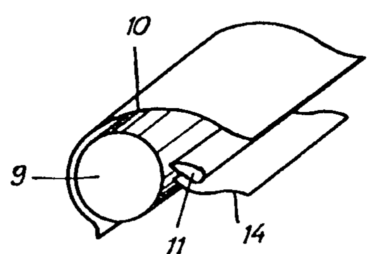


Fig. 1a

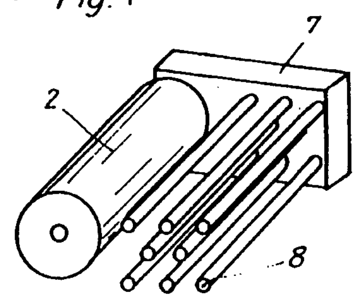


Fig. 1b

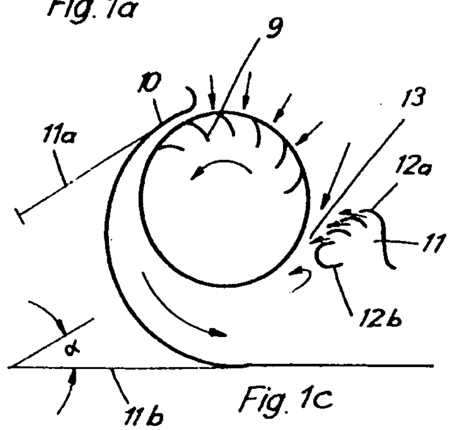


Fig. 1c

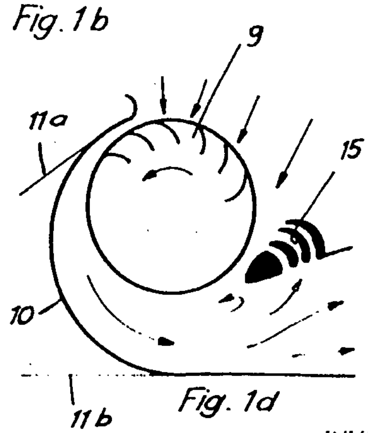


Fig. 1d

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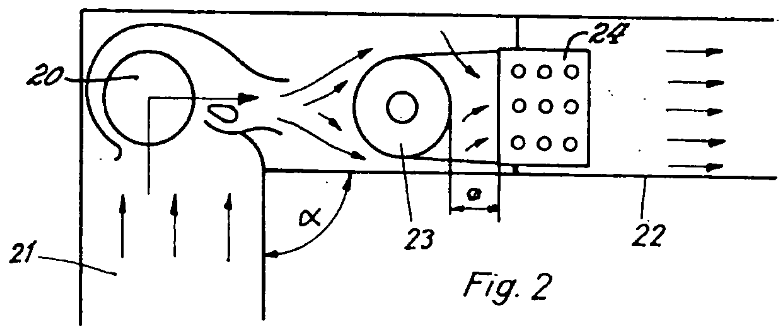

Fig. 2

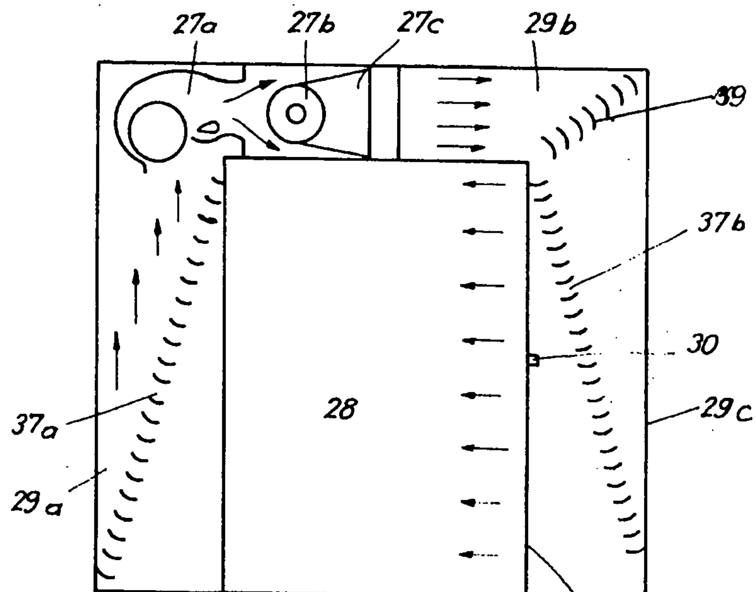

Fig. 3

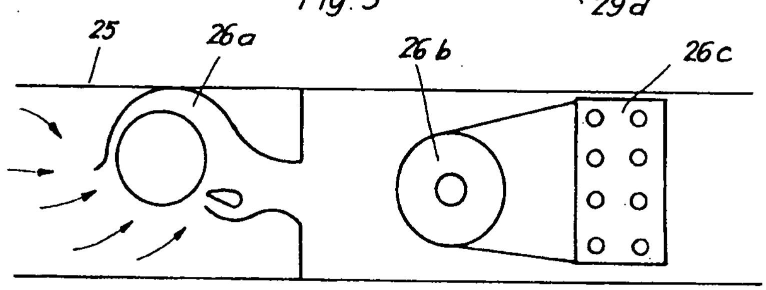

Fig. 4

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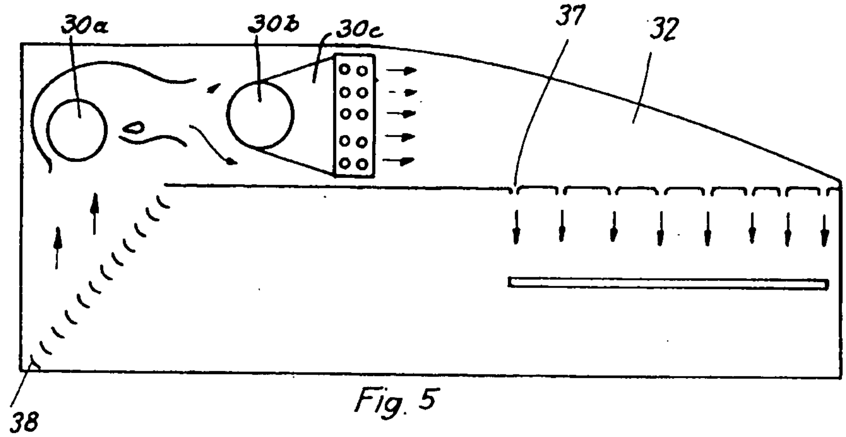

Fig. 5

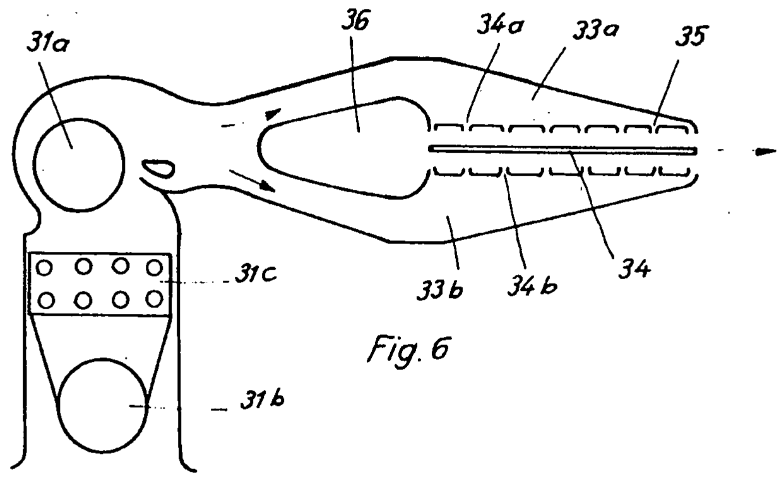

Fig. 6

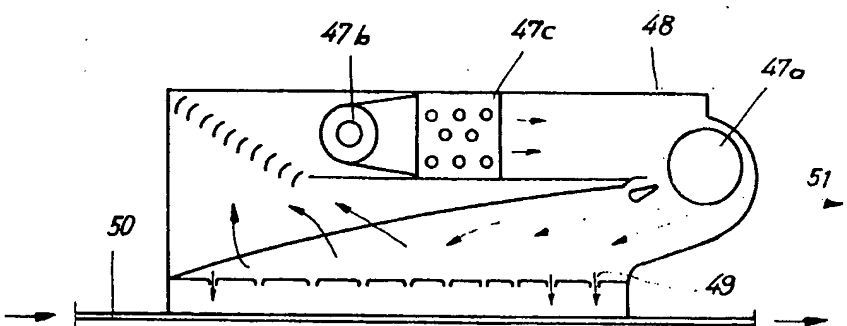

Fig. 7

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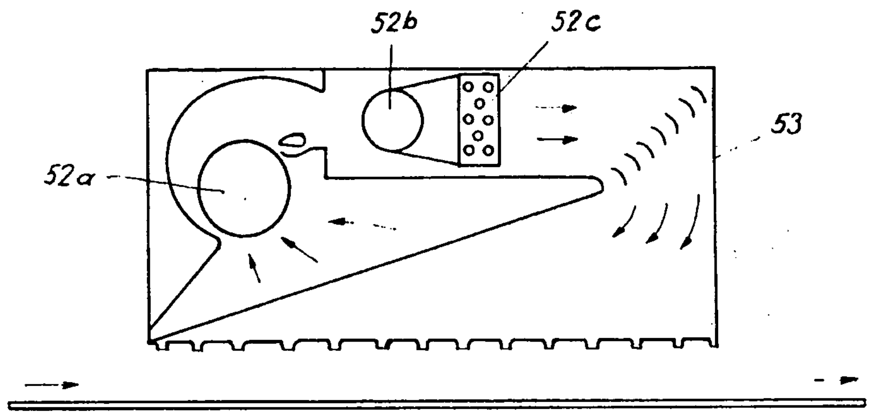

Fig. 8

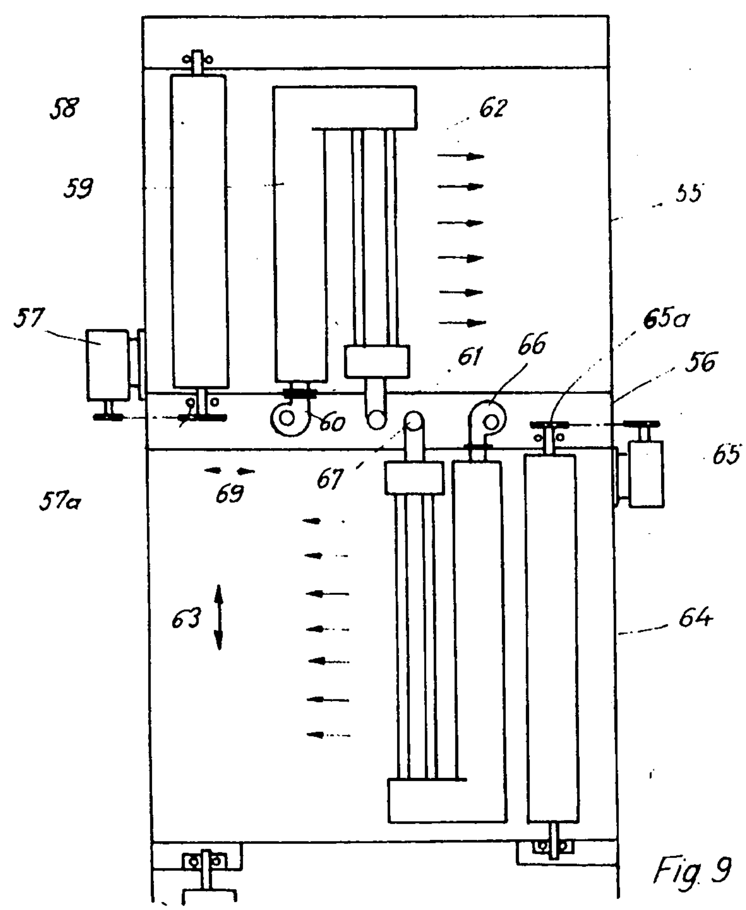

Fig. 9

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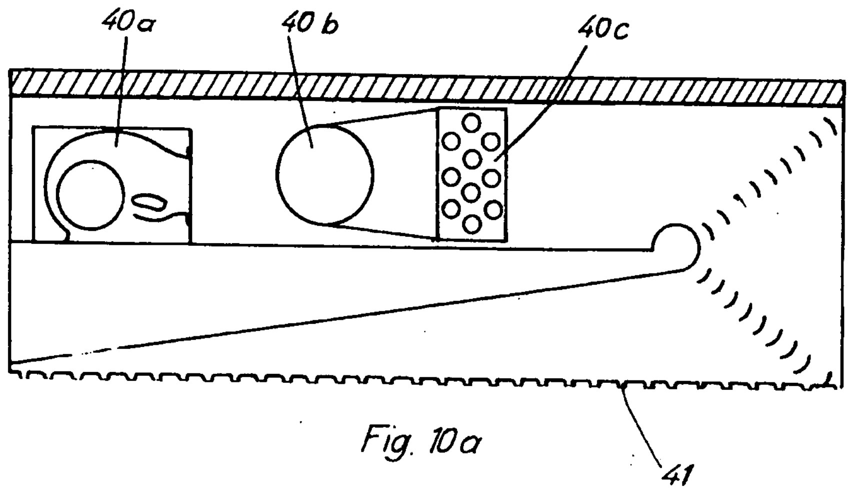

Fig. 10a

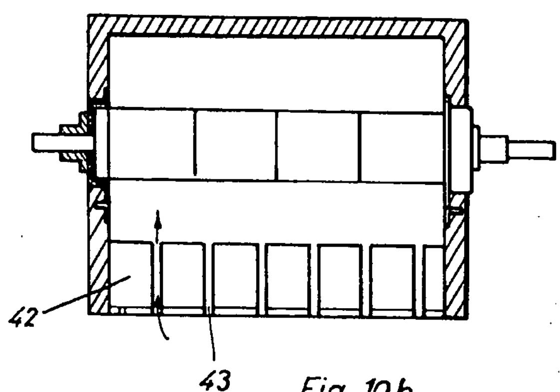

Fig. 10b

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DRIER FOR PARTICULATE OR FIBROUS MATERIAL

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a drier for particulate or fibrous material.

2. THE PRIOR ART

In order to supply long and narrow air channels uniformly with air and heat it has been proposed to use several drum rotors sitting end to end on a common axle. This has the disadvantages that both the velocity distribution and the temperature distribution are irregular, so that hot spots occur, the combustion chamber is inefficiently used, and sensitive points in the overall device lie in the hot airflow. The object of the present invention is to obviate or mitigate these disadvantages.

SUMMARY OF THE INVENTION

According to the present invention there is provided a drier for particulate or fibrous material, comprising a fan for conveying fresh air, a combustion chamber for producing hot gases, a heat exchanger in the path of fresh air for heating the fresh air from the hot gases, and a drying zone for receiving the heated air to dry the material within the zone, the fan being in the form of a crossflow fan, including a cylindrical impeller, a curved deflector plate and a turbulence flap, the deflector plate diverging circumferentially from the impeller in the direction of rotation thereof and enclosing the impeller for an angle of about 180° with the tangents to the deflector plate at the circumferential ends thereof enclosing an angle of less than 90° of the turbulence flap having a surface on the suction side which forms with the impeller circumference a channel widening in the direction of rotation of the impeller and which forms an acute angle with a surface of the flap on the pressure side, the channel being provided for partial return current of conveyed air to the impeller from the pressure side in a direction more or less tangential to the impeller circumference, the axial length of the impeller being considerably greater than its diameter, the impeller, the combustion chamber and the heat exchanger being contained in a casing whose width more or less corresponds to the length of the impeller, and the impeller having bearing and drive units located outside the casing surrounding the impeller.

The device according to the invention has the advantage that, as a result of the shape of the fan, quiescent zones, which can easily lead to hotspots, are prevented from forming, and pressure losses can be compensated for. Moreover, the structure can be lower, without having to accept the considerable pressure losses otherwise to be expected. The distribution of temperature and velocity is well nigh ideal, the flow conditions and thermal efficiency are optimal. Also, the parts of the device can be housed in such a way that they are protected from hot air.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

FIG. 1 is a diagrammatic plan view of a device according to the invention;

FIG. *1a* is a diagrammatic perspective view of a fan of the device in FIG. 1, seen from the side;

FIG. *1b* is a diagrammatic perspective view from the side of a combustion chamber of the device in FIG. 1 with a heat-exchanger exhaust tubes;

FIGS. *1c* and *1d* are diagrammatic side views of modifications of the fan used in the device in FIG. 1;

FIGS. 2, 3 and 4 are diagrammatic side views of various examples of the association of the individual parts of the device according to the invention;

FIGS. 5, 6, 7 and 8 are diagrammatic side views of further variants of the subject matter of the invention;

FIG. 9 is a diagrammatic plan view of an example of the combination of two units of the device according to the invention;

FIG. *10a* is a sectional side view of a further embodiment of the invention; and

FIG. *10b* is a vertical sectional frontal view of the device as in FIG. *10a*.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The drier in FIG. 1 has a fan 1 for conveying fresh air, a combustion chamber 2 in which hot gases are produced, an oil or gas burner 3 being associated for this purpose with said combustion chamber, and a heat exchanger 4, in which the fresh air introduced by the fan is brought into heat-exchanging interaction, in the direction of arrows 6, with the hot gases coming from the combustion chamber, which are first passed through chamber 7, and then exhaust tubes 8. The fan is designed as a crossflow fan, with a cylindrical impeller 9, a curved deflector plate 10 diverging circumferentially from the impeller 9 in the direction of rotation thereof, and a turbulence flap 11. The impeller 9 is driven by a motor and, at both axial ends is contained between closed wall sections or end discs. The curved deflector plate 10 encloses the impeller for an angle of about 180° and tangents *11a*, *11b* to the deflector plate at the circumferential ends thereof enclose an angle less than 90°. On the unenclosed side of the impeller 9 there is provided a turbulence flap 11 (FIG. *1a*) which is wedge shaped and, at a point more or less diametrically opposite to the deflector plate, divides the pressure side from the suction side.

In FIG *1c* end surface *12a* on the suction side forms with the impeller circumference a channel 13 widened in the direction of rotation and encloses an acute angle with a surface *12b* on the pressure side. The channel 13 serves for returning a partial flow to the impeller circumference in a more or less tangential direction thereto. This turbulence flap covers only the smallest possible area of the impeller circumference. In the embodiment in FIG. *1c*, the walls of the wedge-shaped turbulence flap, formed as a hollow body, have inlet openings on the pressure side and outlets on the suction side. In the embodiment in FIG. *1d*, the wedge-shaped turbulence flap has open channels 15 passing through it. However, the arrangement can be such that a baffle plate is associated with the wedge-shaped turbulence flap of the crossflow fan, said baffle plate forming, with the turbulence flap, a channel serving to return a partial flow from the pressure side to the suction side. Such a baffle plate is shown at 14 in FIG. *1a*. The axial length of the impeller is considerably greater than its diameter; it can for example be three to 10 times this diameter. The impeller, combustion chamber 12 and the heat exchanger are furthermore housed in a casing forming a shallow but wide longitudinally extended channel whose width more or less corresponds to the length of the impeller. The bearing and drive units associated with said impeller, for example bearings 16, the projecting part 17 of the burner and the projecting part 18 of the exhaust tubes, are located outside the casing surrounding the impeller. Moreover, the device has in addition a drying chamber in which the heated air acts on material to be dried.

In the embodiment of FIG. 2, a supply section 21 of an air channel leads to a fan 20 with the remaining section 22 of the channel containing a combustion chamber 23 and a heat exchanger 24, the sections 21 and 22 being disposed at an angle of about 90° to one another. However, the arrangement can be such that as in FIG. 4, the air is passed from an inlet into a casing 25 wherein it passes on to the material to be dried along a straight diversion-free path. In this arrangement air is guided without deviation from fan *26a* to combustion chamber *26b* and from there to heat exchangers *26c*. However, the arrangement can be such as that in FIG. 3, in that a withdrawal section *29c* of the air channel, leading the air from heat exchanger *27c* to the material to be dried in space 28, forms with part *29b* of the channel an angle of about 90°, and runs parallel to a supply section *29a*, so that an overall arrangement results in which the supply section *29a*, the withdrawal section *29c*, and the medial part *29b* of the air channel surround the chamber 28 containing the material to be dried on three sides. The part *29b* of the air channel con-

tains fan 27*a*, combustion chamber 27*b* and heat exchanger 27*c*. The withdrawal section 29*c* of the air channel extends along space 28 containing the material, the wall 29*d* of the air channel facing the material being provided with jets 30 for the passage of the air.

In general terms, and as shown in FIG. 5 and 6, heat exchanger 30—*c* or 31*c* can be followed by a channel section 32 or 33*a*, respectively having a wall facing the material to be dried with jets distributed over its entire length. In the arrangement in FIG. 6, combustion chamber 31*b* and heat exchanger 31*c* are on the suction side of fan 31*a* while the pressure side thereof leads directly to two mutually parallel channel sections 33*a*, 33*b*. The channel sections contain between them a long narrow space 34 for material to be dried, and having walls 34*a*, 34*b* facing said material with jets 35 distributed over their entire length and width. The material to be dried may be passed through the space lying on a belt. In this way ceramic parts, for example, can be dried. In the arrangement in FIG. 6 both parallel channel sections, 33*a*, 33*b* are preceded by a more or less triangular diversion member 36, which introduces part of the air from from the fan into one channel section, and the rest of the air onto the other section. In the arrangement in FIG. 5, combustion chamber 30*b* and heat exchanger 30*c* are on the pressure side of fan 30*a* and lead to a channel section 32 which in turn leads to the space containing the material to be dried, the space having a wall facing said material with jets 37 distributed over its entire length and width. FIGS. 10*a* and 10*b* also show a variant of the subject matter of the invention, in which the air coming from fan 40*a* to combustion chamber 40*b* and heat exchanger 40*c* is led through jets 41 into the space containing the material after a diversion through 90° and then through a further 90°. It is to be seen in particular in FIG. 10*b* that the jets are formed in longitudinally aligned jet section 42 arranged side by side and extending over the entire length of the corresponding channel section. Passages 43 are left between the sections 42 through which passages part of the air blown onto the material can pass back into the channel section containing the jets.

The use of the crossflow fan described above entails the advantage on the one hand that quiescent zones are eliminated, and, on the other hand, that pressure losses are compensated for, so that a lower construction is possible. The combustion chamber can now be designed as a longitudinally prismatic member, parallel to the axis of the impeller of the crossflow fan, the length of which impeller is considerably greater, for example three to 10 times greater, than the impeller diameter. The length of the combustion chamber can equal the width of the casing forming the air channel. In this way the channel can be optimally exploited as regards heat economy, a low but long-duration heat being created. The distance between the combustion chamber and the heat exchanger is in a ratio of 1:4 to 1:2 to the diameter of the combustion chamber; thus the flow to the combustion chamber can be closed. The crossflow fan current is very turbulent, so that the combustion chamber, bathed in driven air, is very efficiently cooled. Again, the crossflow fan entails the advantage that the diversion of the air through 90°, normal with this fan, involves considerable savings in space in many areas of use. In order to keep the entire flow as uniform as possible, several curved guide plates such as 37*a*, 37*b*, 39 (FIG. 3) or 38 (FIG. 5) can be provided, distributed at regular intervals over the channel width, at the diversion points for the air. The exhaust-guiding tubes of the heat exchanger can also contain, on the inside and preferably extending over a large part of their length, turbulence elements such as 45, (FIG. 1) designed as longitudinally extended spirals, or spirally wound sheet metal, which contribute to making regular the velocity distribution and the temperature distribution. An antiradiation plate can also be incorporated between the sidewall of the casing of the air channel and the facing axial ends of the heat exchanger as shown in dotted lines at 46 in FIG. 1, said antiradiation plate lying at a certain distance from the casing or channel wall, and from the heat exchanger, and being bathed and cooled from both sides in driven air.

FIGS. 7, 8 and 9 in particular show another important feature of the invention. The arrangement can be such that the fan, the combustion chamber and the heat-exchanger are contained in an air channel which has an inlet for fresh air and an outlet for hot air, said air channel, with suitable casing walls, forming an independent and self-containing unit, several of such units being capable of being combined longitudinally or laterally. FIG. 7, for example, shows such a unit, with a fan 47*a*, combustion chamber 47*b* and heat exchanger 47*c* contained in a casing 48, from which the heated air passes through jets 49 onto conveyor belt 50 carrying the material to be dried. These casings can for example be combined longitudinally in the direction of arrow 51. FIG. 8 shows a similar arrangement with fan 52*a*, combustion chamber 52*b* and heat exchanger 52*c* contained in a casing 53, forming with said casing an enclosed independent unit. Within such a self-contained independent unit, the fan drive, the burner and the exhaust tubes of the heat exchanger are preferably accessible from the outside and from the same side. FIG. 9 shows an embodiment in which a casing 55 of the unit has a nichelike longitudinal compartment 56 extending over the entire length of the unit, and in which are housed drive 57 for fan 58, the part of the burner 60 projecting out of combustion chamber 59, and the part 61 of the heat exchanger exhaust tubes 62 which is accessible from outside. In the embodiment in FIG. 9 the arrangement is advantageously also such that the casings of two adjacent units 55 and 64 combined breadthwise in the direction of arrow 63, have their respective nichelike compartments 56 facing each other so that the drives 57 and 65 and bearings 57*a* and 65*a*, the projecting burner parts 60 and 66 and externally accessible exhaust tube parts 61, 67 of both units are in one line. This means that the units are offset at 180° to each other, relative to the direction of the longitudinal axis (arrow 69), and to the direction of the lateral axis (arrow 63). This results in a particularly advantageous, compact construction.

What I claim is:

1. A drier for particulate or fibrous material, comprising means forming an airflow path, a fan in said path for conveying fresh air means in said path, forming a combustion chamber for producing hot gases, a heat exchanger in the path receiving said hot gases from the combustion chamber for heating the fresh air from the hot gases and a drying zone in the path for receiving the heated air to dry the material within the zone, the fan comprising a crossflow fan, including a cylindrical impeller, a curved deflector plate and a turbulence flap, the deflector plate diverging circumferentially from the impeller in the direction of rotation thereof and enclosing the impeller for an angle of about 180° with the tangents to the deflector plate at the circumferential ends thereof enclosing an angle less than 90°, the turbulence flap having a surface on the suction side which forms with the impeller circumference a channel widening in the direction of rotation of the impeller, and which forms an acute angle with a surface of the flap on the pressure side, the channel providing a partial return current of conveyed air to the impeller from the pressure side in a direction substantially tangential to the impeller circumference, the axial length of the impeller being considerably greater than its diameter, a casing, the impeller, the combustion chamber and the heat exchanger being contained in the casing, in which the width of the casing substantially corresponds to the length of the impeller and the impeller has bearing-and-drive units located outside the casing wherein, seen in the flow direction of the air, the combustion-chamber-forming means follows the impeller and the heat exchanger follows the combustion chamber, the casing including means to lead air without diversion from the fan to the combustion chamber and past the combustion-chamber-forming means to the heat exchanger.

2. A drier according to claim 1, wherein the drying zone has an inlet and the casing includes means to lead air from said inlet to the drying zone along a straight path.

3. A drier according to claim 1, wherein the casing includes a supply section for leading air to the fan and a succeeding section, the supply section forming with the succeeding section an angle of about 90°.

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4. A drier according to claim 1, wherein the casing includes a withdrawal section for leading the air from the heat exchanger to the drying zone and a preceding section, the withdrawal section forming with the preceding section an angle of about 90°.

5. A drier according to claim 4, wherein the withdrawal section extends along the drying zone and has a wall facing the zone provided with jets to allow the air to pass through.

6. A drier according to claim 3, wherein the casing includes a supply section, a withdrawal section, and a medial section containing the fan, combustion chamber and heat exchanger, said section forming between them a drying chamber and surrounding the drying chamber on three sides.

7. A drier according to claim 1, in which the casing includes a section following the heat exchanger and having a wall facing the drying zone with jets distributed over its entire length.

8. A drier according to claim 1, wherein the combustion chamber with the heat exchanger precedes the fan in the path, and the path includes two parallel channel sections following the fan and containing between them the drying zone, the walls of said sections facing the zone having jets distributed over their entire length and breadth.

9. A drier according to claim 8, wherein the walls containing the jets contain between them a longitudinally extended narrow drying zone.

10. A drier according to claim 9, wherein a triangular deflecting member is positioned in said path ahead of said parallel sections which passes one part of the air from the fan into the one channel section, and the other part of the air from the fan into the other channel section.

11. A drier according to claim 1, wherein said casing includes a section leading to the drying zone and having a wall facing the zone with jets distributed over its entire length and breadth, said combustion chamber and heating chamber being located between said fan and said section.

12. A drier according to claim 11, wherein the jets are arranged in rows extending over the entire lengths of the corresponding individual sections, said rows of jets lying next to one another, passages being left between them, through which part of the air blow onto the material can pass back into the channel section containing the jets.

13. A drier according to claim 12, wherein the distance between the combustion chamber and the heat exchanger is in a ration of 1:4 to 1:2 in relation to the diameter of the combustion chamber.

14. A drier according to claim 12, wherein the tubes of the heat exchanger for the exhaust gases from the combustion chamber contain turbulence elements extending over a large part of their length, comprising longitudinally extended spirals.

15. A drier according to claim 1, wherein the fan, the combustion chamber and the heat exchanger are contained in said flow path, said flow path having an inlet for fresh air and an outlet for hot air, said flow path forming means including casing walls forming an independent and self-contained unit, several such units being capable of being combined, at least the drive for the fan, the burner and the exhaust gas tubes of the heat exchanger being accessible from the outside from the same side of the combined units.

16. A drier according to claim 15, wherein the casing of a unit has on one side a longitudinal nichelike compartment extending over the entire length of the unit, the drive for the fan, the part of the burner projecting from the combustion chamber, and the outwardly accessible part of the exhaust tubes being housed in said compartment.

17. A drier according to claim 16, wherein the casings of two units combined widthwise have a common compartment containing the drives, projecting burner parts and outwardly accessible exhaust tubes of both units, the units associated with the common compartment being offset relative to one another relative to the longitudinal axis and relative to the lateral axis by an angle of 180°.

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